ORIGINAL

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Advanced Television Systems	)	
and Their Impact Upon the	)	MM Docket No. 87-268
Existing Television Broadcast	)	
Service	)	
	)	
Fifth Further Notice of	)	
Proposed Rule Making	)	

REPLY COMMENTS OF HITACHI AMERICA, LTD.

Jack S. Fuhrer
Senior Director

John G.N. Henderson
Chief Researcher

August 12, 1996

Hitachi America, Ltd.
307 College Road East
Princeton, NJ 08540
(609) 520-1320

TABLE OF CONTENTS

SUMMARY

Hitachi America, Ltd. (HAL) urges the Commission to adopt the ATSC Standard in its entirety. The system described by this Standard embodies the best and most thoroughly tested digital television technology that is available world-wide. It provides for flexible video and data services, and it allows within itself evolution of new services. HAL believes that if the Commission does not seize the opportunity to create this Standard now, U.S. digital television technological leadership will have been squandered.

HAL notes that some commenters on the Fifth Notice of Proposed Rule Making objected to all or part of the ATSC Standard and proposed an alternative system for the Commission's consideration. In these Reply Comments, HAL will address those specific objections where HAL believes that it has expertise. HAL will also reaffirm, based on the experience gained from its long and deep involvement with the ACATS testing and selection process, that no system can be considered until it has endured the public scrutiny and the testing of a real-time hardware embodiment that was central to the ACATS recommendation.

HAL also comments on the issues of decoder costs for both the ATSC Standard system and for the system proposed by CICATS and DemoGraFX. These Reply Comments will show that low-cost decoders are practical for the ATSC Standard. After analysis of the CICATS proposal, HAL will show that the cost of low-end ATSC decoders is less than the cost of the CICATS base layer decoder. The same analysis shows that the ATSC Standard HDTV decoder costs less than the CICATS HDTV decoder. When these corrected decoder costs are entered into CICATS own cost

model, it is seen that the system described by the ATSC Standard offers dramatic savings in consumer dollars compared with the CICATS proposal.

HAL wishes to reaffirm the importance of maximum interoperability of the U.S. Standard with other international standards for video products and video exchange. In particular, ACATS and the Grand Alliance maintained maximum compliance with the MPEG-2 video standard. The CICATS proposal is not compliant in many ways, as these Reply Comments will describe. By so failing this test of utility and interoperability, the CICATS proposal is weakened further.

Given the advantages, which HAL and other commenters have argued, for setting a Standard, HAL urges the Commission to adopt the ATSC Standard forthwith.

REPLY COMMENTS RELATED TO THE FIFTH NOTICE OF PROPOSED RULE MAKING

Hitachi America, Ltd. (HAL) files the following Reply Comments in response to Comments received by the Commission regarding the Fifth Further Notice of Proposed Rule Making released on May 20, 1996 in the above-referenced proceeding.

Hitachi America, Ltd. (HAL) commends the Commission for continuing to guide the ATV selection process and for the Commission's proposal to adopt the ATSC DTV Standard. HAL believes that the Grand Alliance system provides world leadership in technology and in provision for flexible evolution.

HAL continues to urge that the Commission set a standard and that that standard be the complete ATSC Standard. Absent a standard set by the Commission, a universal digital broadcast service will evolve very slowly, if at all, and it will likely be based on the standards work going on elsewhere in the world; the U.S. advantage will have been squandered.

In these Reply Comments, HAL will address some specific objections of those who oppose the ATSC Standard. HAL will concentrate on technical issues where HAL has expertise and where HAL has already contributed to the ATV selection process and to the public record. HAL will speak particularly to some of the points raised by the Computer Industry Coalition on Advanced Television Service (CICATS) and by its members. Included in these Reply Comments will be: 1) examination of the issues of receiver costs for an ATSC Standard receiver; 2) examination of some of the cost claims for the CICATS and DemoGraFX system proposals; 3) discussion of the ways in

which the CICATS proposals depart from compliance with recognized and tested international standards such as MPEG; and, 4) some comments on scalability, with particular reference to the system proposed by DemoGraFX. We will begin, however, with a reaffirmation of the absolute necessity for the kind of thorough and objective testing of fully operational real-time hardware that was the linchpin of the ACATS process; no alternative to the ATSC Standard should be considered, in our view, unless it has endured such scrutiny

I. Objective testing of fully operational hardware is a pre-requisite for consideration of any system proposals.

The Commission and its Advisory Committee (ACATS) wisely set up a thorough review and testing process as a prerequisite for consideration of any Advanced Television (ATV) proposal. This process included a peer review with public questioning while proposals were at the "paper" stage. Many less effective systems were eliminated at this stage. The process went on to design tests of all aspects of the system; included in the test set were general tests applied in identical ways to all systems and "system-specific" tests designed to explore unique aspects and potential weaknesses of each system specifically.

HAL employees participated heavily in these processes of review and testing. In particular, we were members of the Working Parties that conducted the peer review and that designed the tests. The Chief Researcher of HAL's television laboratory chaired the Task Force that designed and conducted the System-Specific Tests. He also chaired the ACATS Technical Subgroup's Transmission Experts Group, which was responsible for reviewing the transmission-related test results and analysis and making the system recommendation to the Technical Subgroup. HAL participated in and

supported these industry activities because we regarded them as necessary in order to select an ATV system. It is a premise of any such testing process that the unsupported claims of system proponents must be examined before the system is taken seriously; proponent-controlled demonstrations of completely new systems cannot be a basis for consideration. It is a further premise that testing of compressed digital video must include a large variety of test images in order to explore the trade-offs in the proposed compression algorithms; such testing requires the construction of real-time hardware in order to carry out the necessary amount of testing and in order to assess the practicality of the system proposal.

HAL notes that the proposal of CICATS and DemoGraFX does not meet the above standards for objective review, construction, and testing that the Commission and ACATS found necessary. To HAL's knowledge, there has been no full disclosure of the system (the descriptions in the DemoGraFX comments are not complete), no review and serious questioning, no construction of hardware, and no testing using material specifically designed to explore weaknesses (as was done to all systems considered by ACATS). HAL notes further that testing is even more critical for scalable systems, such as that proposed by DemoGraFX, than for non-scalable systems, such as the ATSC Standard, because scalable systems have significantly more complex performance trade-offs. Scalable systems are also significantly more difficult to specify and implement completely. It is a generally accepted fact that scalable systems result in decreased compression efficiency. Proof-of-performance of the CICATS proposal is lacking.

HAL believes that the Commission must not consider the CICATS and DemoGraFX system proposal or any other new system without critical examination and testing of complete hardware. HAL notes, however, that the appointed time for such testing has

come and gone. The ACATS process was long and open, and it was available to all who passed initial technical scrutiny and delivered testable hardware. Proposals made at this late date, especially when they do not stand up to analysis and when they are offered in the context of fallacious and distorted representations of the ATSC Standard system (these points will be covered in detail in the rest of these Reply Comments), seem more likely merely to delay the advent of a new service than to create any opportunity for improvement

HAL notes that the experiences of the ACATS testing process support the need for the Commission to adopt a defined and complete Standard, rather than permit the unspecified evolution of a variety of systems. A Standard codifies a system that is well-defined, well-understood, determined to be practical, and thoroughly tested. Lack of a Standard permits systems with unknown characteristics and performance to enter the marketplace. The marketplace will reject the worst of these systems, but marketplace testing of multiple new systems imposes a very high cost on consumers and would delay or preclude the desired migration away from NTSC.

II. Receivers for the ATSC Standard system can be constructed at a variety of prices, including low-cost designs suitable for set-top boxes for use with legacy NTSC receivers; there is no requirement for full HDTV-level decoder logic to view an ATSC Standard HDTV signal on an SDTV-level receiver.

HAL's television laboratory has described and demonstrated publicly (including demonstrations to Chairman Hundt and at the *en banc* hearings) that "All-Format Decoders" (AFD) can be created which can decode the HDTV-level ATSC Standard bit streams at a decoder cost approximately 10% higher than that of SDTV-only (i.e.,

MPEG-2 Main Profile / Main Level) decoders. This permits low-cost set top boxes for legacy NTSC receivers. CICATS claims, in its Comments, that all decoders of the ATSC Standard, if they are not to go "black" on HDTV transmissions, must cost the full amount of HDTV decoders. This claim is false and seems to ignore information already in the public record. It is, however, a recurring theme in the CICATS Comments.

A. The performance of All-Format Decoding is entirely acceptable for the intended purpose of "SDTV-level" images.

DemoGraFX, in a footnote and without supporting evidence, disparages the image quality in AFD receivers. This claim of poor performance is also false. HAL's public demonstrations were early decoder algorithms, and those algorithms did not depend on special encoder practices. Viewers of our demonstrations regarded the image quality as acceptable or good. Since then, we have improved our decoder algorithms to reduce "prediction drift" in the decoded image between I-frames of the ATSC Standard-encoded image. This improved processing is also receiver-only, with no dependence on encoder practices.

HAL has noted, in some of its publications regarding the AFD, that encoder practices friendly to AFD are possible, although they may not be necessary given our improvements in receiver processing. All such encoder practices are 100% compliant with both MPEG and the ATSC Standard. All of the encoder practices cited by HAL are intended for application only when such application would be either neutral or beneficial to the quality of the HDTV image on HDTV receivers. In particular, use of B-frames is beneficial to AFDs (and to all reduced-complexity decoders, including those of interest for personal computers) and has been shown by studies published by other laboratories (Communications Research Centre (Canada), Princeton University) and by MPEG to

offer improved HDTV compression quality. In the matter of the relative distribution of I-, P-, and B-frames, HAL's proposals for encoder practices are well within the ranges of good HDTV encoding practice. HAL has also pointed out constraints on motion vector resolution that can benefit some AFD designs, at some cost to HDTV quality on some images. However, HAL believes that these restrictions will not be needed for well-designed AFDs, and HAL has devised decoder algorithms that match the drift-reduction benefits of restricted motion vectors while using receiver-only processing on images encoded using full HDTV-resolution motion vectors.

HAL's demonstrations included video encoded by other laboratories and supplied to us as examples of image sequences that would be difficult for our algorithms. HAL recognizes that its AFD demonstrations, even though they included difficult images provided by other laboratories, do no meet the rigors of ACATS testing. However, the AFD is an example of a low-cost video decoder implementation -- it does not affect the ATSC Standard or its performance testing, documentation, and selection by the Commission.

B. Given that the practicality of AFD has been demonstrated, there is no economic requirement for a scalable system.

CICATS main argument for the base-line format in their scalable system seems to be low cost. In fact, the AFD that HAL has demonstrated is lower cost than the CICATS base-line system (we will cover this point in detail in later sections of these Reply Comments). There is no economic argument for the CICATS base layer.

C. The CICATS document distorts the public record of supporters of the ATSC Standard.

HAL notes in particular the footnote in the CICATS submission (Volume 1, footnote 95) citing Hitachi America's comments on the Fourth NPRM in favor of receivers that decode all formats. CICATS uses this to support their claim that manufacturers intend to sell consumers high-priced HDTV decoders under threat of blank screens. In fact, as reading our cited Comments shows clearly, HAL argued that the AFD permits lower consumer costs while still decoding all transmissions.

D. The "18 formats" in the ATSC Standard (which HAL thinks could be characterized more accurately as, perhaps, three) cited by CICATS are all decoded by the AFD at the low costs (about 10% higher than the irreducible minimum for SDTV-only decoders) that HAL has indicated in public presentations.

HAL claims, based on reduced memory requirements and a processor of complexity roughly equivalent to MPEG-2 MP@ML (i.e., SDTV-level), that the AFD would cost less than a full HDTV ATSC Standard decoder by a factor of about six. There is a 6x reduction in memory size and also a reduction in memory interface speed. This AFD decodes all "18" of the formats. In contrast, CICATS claims a 4x-6x reduction in memory size; they do not state memory speed, but HAL's analysis of their proposal indicates speed requirements higher than the AFD.

HAL believes that it is more useful and accurate to characterize the ATSC Standard as containing three formats (1080-line, 720-line, 480-line) rather than enumerating the sub-categories of these formats as if they were fundamentally different to arrive at an

exaggerated total of "18." While a single format would probably lead to slightly lower costs in an optimized product, we think that CICATS' implications that the multiple formats dramatically increase costs is untrue.

III. CICATS cost figures and their attendant claims to offer multi-billion dollar consumer savings are unrealistic.

A detailed comparison between the projected costs of the ATSC Standard and the proposed CICATS system is included in Appendix A. The principles and models established by CICATS and Lee Selwyn were used as the basis of the analysis in Appendix A; HAL does not necessarily endorse this approach to cost calculation, but we have used it in these Reply Comments to make the comparisons between CICATS and ATSC Standard clear. The results are summarized below.

The CICATS cost comparison is seriously flawed in two ways. First, it ignores the fact that it is possible to manufacture low cost MPEG-2 video decoders that are capable of decoding all of the ATSC video formats at "standard definition". Second, it is self-contradictory in that it acknowledges that "For complex processes, these requirements [data processing rate and memory usage] translate almost linearly to the cost of the devices required," while failing to take this into account when evaluating the cost of the proposed CICATS base layer decoder. CICATS, in their Comments, state that their base-line decoder is "substantially equivalent in complexity to a DSS decoder," even though the data processing rate for a CICATS base layer decoder is 1.8 times that of a DSS decoder.

In contrast, HAL has established that the costs of a set-top converter for the ATSC Standard will be less than those of a CICATS base layer converter. Based on the CICATS costing model, the video decoder subsystem of a converter for the ATSC Standard will cost 17% more than that of a DSS receiver, while a CICATS base layer decoder subsystem will cost 30% more.

By substituting these figures into the economic model developed by Lee Selwyn for CICATS, it can be projected that, through the end of 2007, consumers would spend $49.6 billion on all-format converters under a scenario that assumes the ATSC system, far less than the $91.7 billion projection in the CICATS Comments, which was based on erroneous assumptions.

At the same time, the corrected economic model projects that consumers would spend $51.1 billion under the CICATS scenario, more than the $47.8 billion projection which assumed, incorrectly that the CICATS decoder would cost the same as a DSS decoder. Thus, combining the CICATS costing model and Selwyn's economic model yields the projection that consumers would *save* $1.5 billion under the ATSC Standard.

While Selwyn's analysis only focused on the costs of converter boxes, HAL has used his assumptions to create an economic comparison of the costs for digital television receivers under the two different plans. HAL's analysis suggests that ATSC Standard receiver decoders would save consumers $1 billion on the decoder subsystems of digital receivers over the same time period compared with CICATS receiver decoders. This cost savings is partly due to the high cost and complexity of the CICATS high definition video decoder.

It is well known that spatially scalable systems for video coding incur added costs for decoding the high level pictures. This is especially true for the CICATS system, where the required processing rate for HDTV decoding is more than double that for the ATSC system.

Perhaps of greater significance than the cost savings under the ATSC scenario is the fact that it would result in wholesale migration of consumer receivers to designs that are capable of receiving transmissions using high definition video formats. Under the CICATS scenario only the most expensive receivers would be capable of decoding high definition bit streams. Thus, under this scenario, the practice of transmitting a multi-level signal would need to be sustained indefinitely, in order to serve both low and high end viewers. This practice would be costly for both broadcasters and consumers, and would needlessly waste the precious spectrum resource.

IV. Compliance with recognized and tested international standards is an important attribute of the ATSC Standard; such compliance facilitates program exchange, lowers consumer costs, and assures the interoperability of the widest possible range of consumer video products.

A firm guideline given by ACATS to the Grand Alliance in development of the system that was to become the ATSC Standard was maximum compliance and interoperability with international standards, especially the MPEG video standard. The ATSC Standard achieves this goal with only a few constraints related to U.S. broadcast applications. In contrast, the system proposed by CICATS and DemoGraFX suffers from non-compliance and non-interoperability with any standard. Detailed descriptions of the areas where the CICATS proposal is not compliant with the MPEG standard are

enumerated in Appendix A of the Reply Comments of the Advanced Television Systems Committee (ATSC).

HAL highlights some key areas of non-compliance:

- Temporal enhancements are incompatible with the MPEG Standard. Moreover, the CICATS method of using the temporal enhancement bit stream is not specified completely.

- The spatial enhancements, as proposed by DemoGraFX, are admitted to be incompatible with the MPEG standard. This is especially troubling since the experience of the MPEG committee suggests that it is much more difficult to specify properly a multi-layered video coding scheme than a single layer scheme.

- The highly restrictive base layer proposed by CICATS would preclude carriage of every known bit of digital TV that is currently transmitted in the U.S. via satellite, cable, MMDS, DVD or Telco TV systems. This would surely have a dampening effect on the vitality of digital television in the U.S.

- B-frames are disallowed in the CICATS base level. This restriction limits encoder flexibility in facilitating reduced cost decoding of the base level. This approach should be particularly onerous to computer CPU-based decoders, since it removes a number of options for graceful decoder degradation.

- The CICATS system is poorly specified. There are ambiguities and missing information in contrast to the formal and complete specifications of the MPEG and ATSC Standards.

V. Claims for 72 Hz Frame Rates and Square Pixels Are Overstated in the CICATS Documents.

The 72 Hz family of frame rates in the CICATS proposal was motivated by the fact that computer CRTs typically scan at rates beyond 60 Hz. In this regard, a number of facts should be noted:

- These scan rates are only relevant to CRT displays, but an increasing number of computer displays are not CRT-based. This is due to increasing sales of LCD based notebook computers, LCD based desktop computer displays, and LCD and DMD data projectors.

- There is no "72 Hz video standard" for computers. Two computers, both of which may indicate a mode with a nominal scan rate of 72 Hz, may actually differ in rate by 1,000's of parts per million. Many computer displays are commonly operated at rates which are far from 72 Hz. For example, the modern Power Macintosh computer used to edit this document offers the user only two scan rates - either 67 Hz or 75 Hz -- depending on resolution.

- There is no standard equipment manufactured anywhere in the world for video acquisition, editing, storage, or transmission at 36 Hz or 72 Hz.

- Support for frame rates as high as 72 Hz may significantly increase the cost of decoder DRAM, due to the speed limitations of inexpensive DRAMs.

- It should also be noted that all of the CICATS base layer decoders would be limited to 36 Hz frame rates. This would be noticeably inferior to the 60 Hz rates supported by all ATSC decoders and the rate provided by NTSC transmissions.

Although CICATS claims that computers "assume square pixels," both the Microsoft Media Player software and the Apple Macintosh Movie Player software permit independent vertical and horizontal scaling of the video window. Thus, non-square pixel video formats are inherently supported by today's software. The one non-square pixel format supported by the ATSC Standard (704 x 480) was included to allow for interoperability with existing digital video systems (DBS, cable, MMDS, DVD), none of which uses square pixel formats.

VI. Proposals for scalable systems, similar to that of CICATS and DemoGraFX, have been made to and examined by MPEG, and they have been found to have poorer performance than the approaches adopted by MPEG.

The scalable or layered aspect of the CICATS approach that is credited with the dramatic improvements in coding gain was, in fact, considered by the MPEG committee. It was proposed by the Netherlands PTT. This approach was rejected because, in objective tests, it performed about 0.3 dB poorer than the spatial scalable approach that was ultimately adopted. There were also concerns of drift, implementation complexity, and increased dynamic range and precision. CICATS claims that its method is substantially more efficient but seems unaware of earlier objective MPEG results.

The MPEG spatial scalable tools initially garnered a great deal of interest in Europe as a means of transmitting HDTV. However, when potential users were confronted by

the penalty in coding efficiency and increased complexity (both for encoders and decoders) the attraction of this approach quickly faded. The only known objective studies comparing CICATS' approach (as initially proposed by Netherlands PTT) and MPEG spatial scalability indicated CICATS' approach to be inferior.

Most digital TV system planners outside the U.S. appear to be assuming a simulcast approach for moving to higher levels of performance. The U.S. has an opportunity to lead the world by anticipating high definition at the introduction of digital television, including the availability of low cost decoders that are compatible with all formats. There will thus be no future need for digital simulcast (which would waste transmission bandwidth and add complexity to the broadcast plant) or scalable video (which also wastes bandwidth and entails significant added cost at both encoder and decoder) until there is a need to move beyond 2 Mpixel resolution (which could be 20-50 years).

VI. CONCLUDING REMARKS:

In these Reply Comments, HAL has considered some of the objections raised to the ATSC Standard system and has examined some of the technical and cost aspects of proposed alternatives. HAL believes that it has established that the considered objections are not valid. HAL also believes that the cost and performance claims by the proponents of alternative systems do not survive careful scrutiny.

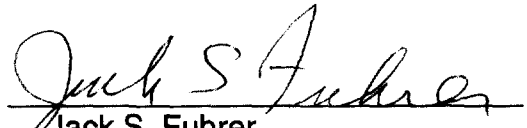
Therefore, HAL urges the Commission to adopt the ATSC Standard forthwith. It has survived objective analysis and testing. It reflects broadcasters' needs for a universal new digital service. It has met manufacturers' requirements for practicality and performance. It offers the best known combination of cost and performance, and it

permits consumer receivers at a wide range of price points. Other attributes of the system defined by the ATSC Standard include spectrum recovery, new broadcast business opportunities, improved television delivery and image quality, and new consumer services. A Commission action establishing the ATSC Standard will provide for both business and consumers the stability needed for investment.

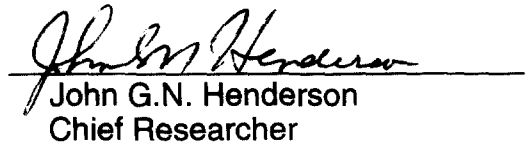
The ATSC Standard offers the Commission an opportunity to codify a system with world technological leadership and the support of a wide range of participating businesses and industries. The Commission must seize this opportunity.

Respectfully submitted,

HITACHI AMERICA, Ltd.

By: 

Jack S. Fuhrer
Senior Director

By: 

John G.N. Henderson
Chief Researcher

307 College Road East
Princeton, New Jersey 08540
609-520-1320

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Appendix A:

COMMENTS ON THE CICATS COST COMPARISONS (AND RELATED SUBMISSIONS)

This section analyzes critically the cost comparison presented in the CICATS Comments as Exhibit C, "Cost Comparison of ACATS and CICATS Set-top Converters, Receivers, and PC Decoders." It also contains comments on the economic forecasts given by Lee Selwyn on behalf of CICATS, which are based on the comparison of CICATS Exhibit C.

The CICATS cost comparison is seriously flawed in two ways. First, it ignores the fact that it is possible to manufacture low cost MPEG-2 video decoders that are able to decode all of the ATSC video formats at "standard definition". Second, it is self-contradictory in that it acknowledges that "For complex processes, these requirements [data processing rate and memory usage] translate almost linearly to the cost of the devices required,"[1] while failing to take this into account when evaluating the cost of the proposed CICATS base layer decoder.

Estimating the relative costs of video decoder subsystems

The cost of the MPEG-2 decoder circuitry in a receiver, computer or set-top converter box can be separated into two parts -- the cost of the integrated circuits (ICs) that perform the video decoding computation and the cost of the associated Dynamic Random Access Memory (DRAM). It will be assumed that each of these parts contributes equally to the cost of the MPEG-2 decoding subsystem within a DSS

[1] CICATS NPRM response, Exhibit C, p. 2.

receiver, which is the benchmark used in the CICATS analysis. In the past six months the market prices for DRAM have decreased very rapidly, due to a worldwide oversupply and weaker than expected demand. Prior to the decline in these prices the DRAM used in the DSS decoder subsystem was more expensive than the MPEG-2 processing IC; today this is the less expensive component. The prices of both DRAM and processing circuitry will continue to fluctuate, but the neutral assumption of equal cost appears justified in the absence of definite information on future pricing. Thus the cost premium of a decoding system can be computed by:

$$\text{Prem\_XYZ\_decoder} = 0.5 * (\text{XYZ\_decoder\_DRAM} / \text{DSS\_DRAM}) + 0.5 * (\text{XYZ\_decoder\_processing\_rate} / \text{DSS\_processing\_rate})$$

The definition of the term premium in this Appendix is the ratio of predicted cost of the given video decoder subsystem to the cost of the DSS video decoder subsystem.

Note that the DSS decoder subsystem uses 2 MBytes of DRAM (DSS_DRAM = 2 MBytes), and is capable of video decoding at a rate of 10.4 Mpixels/sec (DSS_processing_rate = 10.4 Mpixels/sec). Applying the principles described above yields the figures shown in Table 1.

In Table 1, Prem_AFD_decoder represents the cost premium of an all format decoder (AFD) subsystem for the ATSC Standard, relative to the cost of the DSS decoder subsystem, using the CICATS costing model[2]. The AFD is capable of decoding all of the ATSC Standard video formats, for presentation at standard

[2] For reference, the CICATS model implies that the DSS decoder subsystem contributes $213 to the retail price of a DSS receiver.

definition. The AFD requires 2 MBytes of DRAM (same as DSS), and a maximum pixel processing rate that is 1.33 times higher than that of DSS.

Cost premium for AFD decoder (relative to DSS decoder)	Prem_AFD_decoder	117%
Cost premium for ATSC HD decoder (relative to DSS decoder)	Prem_ATSC_HD_decoder	550%
Cost premium for CICATS decoder (relative to DSS decoder)	Prem_CICATS_decoder	130%
Cost premium for CICATS HD decoder (relative to DSS decoder)	Prem_CICATS_HD_decoder	828%

Table 1 - Relative Costs of Video Decoder Subsystems for ATSC Standard and Proposed CICATS System, and Related Parameters (Note that the definition of premium as used in this Appendix is given on the previous page.)

The cost premium for a full HDTV decoder for the ATSC Standard is given in Table 1 with the label Prem_ATSC_HD_decoder. The figure used here arises from the fact that this decoder requires five times the memory and six times the processing capability of the DSS decoder. Note that this is higher than the 500% premium assumed by the CICATS analysis.

A more realistic estimate (*i.e.* one which follows CICATS own cost model) of the cost premium for the CICATS base layer decoder subsystem is given in Table 1 with the label Prem_CICATS_decoder. The CICATS base layer decoder uses the same amount of DRAM as the DSS decoder, but processes picture data at an 80% higher rate. Although these facts would lead to a 140% cost premium, this number was reduced to 130% to take into account the fact that the base layer decoder does not need to process B frames[3] This is a generous allowance, considering that there is little processing circuitry saved by the avoidance of B frames. The assumption made by

[3] In MPEG-2 video coding *B frames* are those which may use bi-directional prediction.

CICATS that the cost of a decoder for their proposed base layer would equal that for DSS is clearly unjustified in light of their own costing model.

The cost premium for a full HDTV decoder as described in the DemoGraFX submission is given the label Prem_CICATS_HD_decoder in Table 1. This figure was derived from the total of 8.5 MBytes[4] of DRAM required and maximum processing rate of 128 Mpixels/sec.

Comparison of economic implications of ATSC Standard and proposed CICATS system

The economic model created by Lee Selwyn for CICATS is flawed because it fails to take into account the cost premium of a CICATS base layer decoder, as described above. It also incorrectly assumes that set-top converter boxes for adapting existing NTSC receivers to the ATSC digital television system will include full high definition decoders. In reality, it is expected that set-top converters for the ATSC system will contain standard definition AFD decoders.

This section duplicates the analysis performed by Selwyn, with the two corrections outlined above. The basic parameters used are shown in Table 2, which are all identical to those used by Selwyn.

[4] Although the DemoGraFX proposal only tallies 8 MB of DRAM, it fails to consider the cost of the necessary buffer for temporary storage of compressed video data. At least 0.5 MB would be required for this purpose, in order to allow for high quality coding of difficult pictures.

Present price of DSS receiver	PDSS	$500
Present fraction of DSS not subject to Moore's law	HW	15%
Present fraction of DSS subject to Moore's law	VLSI	85%
Fraction of VLSI for MPEG-2 decoding	MPEG	50%
Moore's law - number of years for price to drop by half	Half_life	2

Table 2 - CICATS parameters used in the economic model

A corrected economic forecast is shown in Table 3. The shaded columns are identical to those derived by Selwyn. The unshaded columns were computed as follows:

PXYZ = PDSS * (HW +

VLSI * [(1 - MPEG) + MPEG * Prem_XYZ_decoder] * 2^(-(year-1996)/Half_life))

Table 3 compares the cost to consumers for purchasing set-top converter boxes for their existing NTSC receivers under the CICATS and ATSC scenarios. All converters for the ATSC system are assumed to be based on low cost all format decoders.

The results given in Table 3 are in striking contrast to the analysis produced by Selwyn. The total amount to be spent on receiver conversions through the end of the year 2007 under the CICATS scenario is projected to be $51.1 billion, $1.5 billion more than the projected $49.6 billion to be spent under the ATSC Standard.

	PCICATS (base layer receiver)	PAFD (all ATSC formats at standard definition)		Annual CICATS converter costs ($000)	Annual AFD converter costs ($000)
1996	$564	$535		0	0
1997	$421	$401		0	0
1998	$319	$305		7,425,468	7,096,093
1999	$248	$238		5,420,607	5,201,478
2000	$197	$190		8,196,019	7,901,603
2001	$161	$156		5,736,142	5,558,133
2002	$136	$133		6,292,512	6,128,757
2003	$118	$116		5,691,840	5,571,245
2004	$106	$104		4,501,521	4,425,996
2005	$97	$95		3,263,608	3,221,304
2006	$90	$89		2,325,380	2,302,572
2007	$86	$85		2,227,452	2,211,198
TOTALS				51,080,549	49,618,379

NOTE: shaded columns are identical to those produced by Selwyn

Table 3 - Total consumer cost of ATV conversion comparing CICATS base layer converters with all format decoders (AFD) for the ATSC system

We emphasize our purpose in presenting these analyses. HAL does not necessarily endorse either the methods or cost assumptions associated with Table 3. Rather, we have deliberately followed the CICATS methods to establish a comparison that is consistent with their assumptions and models.

Economic comparison of new receiver sales

It is interesting to compare the economics of digital receiver sales under the two scenarios. Only the costs of the video decoder subsystems are considered. It should be noted that the CICATS use of a 72 Hz family of picture rates would likely add additional cost to cathode-ray tube (CRT) based CICATS receivers. This factor was not included in the present analysis.